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3D Models in Settlement Research – Potentials and Drawbacks of Digital Models as Scientific Working Tools and for Presentation to Non-Professionals

Abstract: The use of computers in almost all facets of personal and professional life continues to increase. It goes without saying that this change occurs in different areas in different ways. A far-reaching tool for addressing spatial questions in settlement research could very well be the 3D model. Due to their visibility and versatility, 3D models can be of great importance for anything from scientific analysis to public presentation. The possibilities for using the models in settlement research have, as of today, barely been examined and have therefore been chosen as the topic of this paper.

Introduction

Settlement research is, by its nature, an interdisciplinary field. Typically, archaeologists, historians and geographers are involved in this work. If the investigation of historic settlements is connected to future planning processes of settlements and cities, architects and urban planners also get involved.

Spatial settlement analysis is a common procedure for combining the past and the future. In this process, spatial relations between multiple elements of the settlement are investigated. Changes in the settlement over time, its historical development and systems of classification are all considered in this work. The aim of the investigation is to make forecasts for future development by analyzing the past (Straub 2007).

When analyzing the historical development of settlements, existing building structures as well as deserted buildings have to be looked at. By deserted we mean that the building structures no longer exist. In addition to the scientific work, the presentation of the results to non-professionals is important. This applies to both existing and deserted buildings. Researchers look at the reconstruction and processing of deserted buildings with digital 3D models very critically. Other than for public presentations, there is almost no scientific use for 3D models in settlement research and settlement analysis to date.

On the other hand, non-professionals generally appreciate 3D models for their ability to vividly depict the past. Nevertheless, it has been found that viewers do begin to tire of the heavy use of technology. The question of whether virtual reconstructions are truly scientific has been in dispute for a long time. In research circles, scientists struggle to take "virtual worlds" out of the niche of presentation gimmicks like "Disney World" and into serious scientific discussion.

The great potential of 3D models has however not yet been clearly defined and methodically investigated. One of today's vanguards is Prof. Barceló of the Universitat Autonoma of Barcelona, who has been proclaiming the virtues of virtual reconstructions for scientific use for many years (Barceló 2001). A new and promising approach for the further development of virtual reconstruction methods is the "London Charter" initiative. The work group of Prof. Beacham from Kings College in London has suggested general guidelines and uniform methods as best practice for virtual reconstructions. The self-proclaimed aim of the initiative consists in "establishing internationally-recognized principles for the use of three-dimensional visualization by researchers, educators and cultural heritage organizations" (Beacham / Danard / Niccolucci 2006).

All efforts in this direction aim towards using 3D visualizations for scientific rather than for presentation purposes. The main question is how to balance knowledge transfer among scholars and to a public audience. A description and review of the possibilities of using digital 3D models in settlement research offers support to those involved and can perhaps contribute to the better understanding of the potential of the models for scientific work. This paper describes some aspects of methodical approaches for the use of 3D models.

Problem Description

To date, investigations on completed settlement reconstruction projects have merely shown that after a project ends, the results are at times documented as 3D models embedded in movies or interactive presentations. Despite years' long controversy, the amount of visualizations for presentation purposes continues to grow. Yet in the scientific community, models are still only rarely used in research.

Why does this imbalance exist? What makes it so difficult to use 3D models in research and why on the other hand are such great efforts undertaken to create these models for public audiences? Most experts agree that for public use, 3D models are very efficient for creating images, but for scientific use, the experts hesitate and remain extremely skeptical.

Surveys by the author show that researchers assume that:

- It takes much time and effort to create 3D models.
- The software is very expensive.
- No images should be shown because of the factor of uncertainty.
- 3D models do not increase scientific value.
- 3D models do not support scientific work and are therefore not needed.

These opinions are in part understandable, but are not held by all people involved. A huge part of the existing attitude is lack of knowledge about the media and its possibilities. Our hypothesis suggests that the development of systematic knowledge about the possibilities offered by 3D models in settlement research and analysis will support the use of the models and will improve scientific results. If it can be proven that models support scientific work then it would be desirable that they be used more often in future projects to work in a process-oriented way.

Theoretical Superstructure

Digital 3D settlement models can be classified into two main types:

1. Models of existing settlement structures.
2. Models of deserted settlements or settlement areas.

The 3D representation of existing buildings based on aerial laser scan data or aerial maps involves different techniques and requires a more technical approach than the task of building 3D models. The question in this case is how to gain a great deal of data in a short time. The best method is a combination of automated and semi-automated methods (Raheja 2005). Because of commercial interest in this field, the research is very well developed. In the last few years, several research projects have come out that provide solutions for the automated modelling problem.

The primary uses for these 3D models involve city planning, mobile phone pole placement and the development of navigation systems. The modelling of former settlements is a secondary use for the technology. Without a doubt, the representation of former structures is, by the nature of its unclear content, much more difficult. The main use of 3D models of deserted settlements is still for effective public presentations rather than research. Unlike existing buildings, it is much more complicated to form statements about a settlement that no longer exists. For this reason, it is not just a question of efficiency; rather the challenge is finding the right pieces of the puzzle to make hypotheses about the past.

The application of digital 3D models has hardly been methodically investigated at all. The use of GIS systems, for example, for historical processes that involve time, space and several hypotheses is just beginning. It is the aim of the current research to create guidelines and standards to strengthen models as a scientific method. This novel field of work requires the development of methods for the use of digital media in analogue settlement research. Therefore, the emphasis of work has been brought to two main aspects of these usually separated types of research:

1. What questions are important for the reconstruction of a settlement?
2. What opportunities do digital tools, and in particular 3D models, offer?

Fig. 1 shows two main aspects of the work. The upper part of the illustration shows two of the main cases in which 3D models can be used effectively. Settlement analysis is the method commonly used to analyze structures from the past in order to make predictions about future development. As with research work, settlement analysis on deserted settlements tries to understand the development of a settlement over time. In both research work and settlement analysis, the structures under investigation usually no longer exist as complete structures. Therefore, the reconstruction data is very vague and normally very fragmented. In order to aid the reconstruction attempts, it is possible to take purely geo-

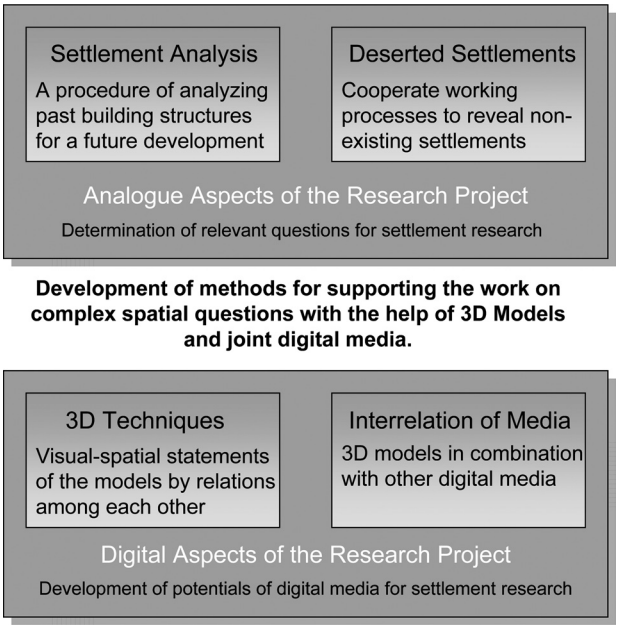

Fig. 1. Scheme of the Working Method (S. Baumeier).

metric models and use them for simulations (light simulation, view-axis investigation) or to combine the geometric representations with other non-spatial attributes. Both approaches offer different possibilities and can help answer questions about the settlement or support the generation of new questions that had not been focused on before 3D models were used.

Analogue Settlement Research

The field of settlement research is carried out mainly by archaeologists, historians and geographers (Jankuhn 1977). Over the last several years, the methods of analysis of deserted settlements have hardly changed. Real progress towards a modern computer-based approach to the work has not been made. The most progressive approach has been taken by the working group ARKUM (Arbeitskreis für historische Kulturlandschaftsforschung in Mitteleuropa, www.kulturlandschaft.org), an internationally renowned group of experts from the participating fields. This group regularly meets to discuss and present new approaches to both analogue and digital working methods.

One of the aims of research into deserted settlements is to find answers to questions about the beginning, the phases of change and the end of a single building or the whole settlement site. In order to define the boundaries of the work, ways of classifying non-existent structures have been investigated.

Although there are several other schemes, *Tab. 1* shows the most recent and formally complete. It covers several types of deserted settlements, buildings and parcels of land and also takes the factor of time partially into consideration (A'B'C'D'). The table shows four different categories of settlement structures (City, Village, Solitary Courtyard, and Place of Work) and records them in relation to different degrees of desertion of settlements and parcels of land. The scheme offers a great number of possibilities for visualizing these typologies. By analyzing the scheme, one can find different levels of information for reconstruction. A city that is totally deserted, surrounded by a totally deserted parcel of land (AI1), is by the nature of the physically remaining data more difficult to reconstruct than a partially deserted, solitary courtyard with a remaining non-deserted section (DIV4). The scheme supports the reconstruction process and can be seen as a tool for measuring the credibility of a virtual reconstruction.

Category		**Settlement**		**Parcel**	
A	City a.) District	I	Totally Deserted	1	Totally Deserted
B	Village b.) District	II	Partially Deserted	2	Partially Deserted
C	Solitary Courtyard	III	Temporally Totally Deserted – Reconstruction A' B' C' D'	3	Temporally 1 Totally 2 Partially
D	Place of Work	IV	Temporally Partially Deserted – Reconstruction A' B' C' D'	4	Not Deserted

Tab. 1. Scheme on Deserted Settlements and Parcels (after Wenzel 1990).

Digital Approaches

There are two ways to use 3D models for scientific purposes in settlement research. The models can be used purely as models, taking advantage of all the features normally associated with 3D models, such as geometry, viewing positions, textures, lighting, dynamics by movement etc. Additionally and importantly, 3D models can also be combined with other data sources and media types that are available for settlement reconstruction. It is necessary to find ways of combining the pure model with many different types of data. The data sources depend on the emphases of the research, such as archaeology, geography or history. In specific areas, several sources of data are available, though not always in sufficient quantity or quality. Only by combining the existing data can the uncertain past be clarified, piece by piece.

3D models could potentially support the orientation and management of these manifold sources very well. At present, these techniques are still not available. The most promising piece of technology currently available is GIS. Due to the great relevance of showing changing processes, the ability to handle time has been included in GIS via the so-called 3D/4D-GIS. These techniques allow the user to combine spatial information with a 2.5th and 3rd dimension as well as with historical events. The combination of GIS data and 3D models has just begun to be explored. More and more software providers realize the potential of this and have started producing GIS-enabled applications. One example is the 3D Modeller SketchUp for Google Earth (http://sketchup.google.com/).

In addition to the two aspects that shall be investigated in depth, an analysis of current methods and practices of creating 3D models has been started. So far, the London Charter is the most promising approach in terms of enabling 3D models to become scientific tools. The London Charter states that 3D models should be planned and documented in much more scientific ways. It also becomes clear that the proposed practices are rather general. Every special area that uses 3D models has to define its own methods based on the basic principles of intellectual integrity, reliability, transparency, documentation, standards, sustainability and access. The London Charter initiative is very relevant to the research project because it sets the foundation for the specific requirements for working with 3D models in settlement research.

The present use of 3D models for scientific reasons in research projects on settlements could not, by the definitions of the London Charter, be explicitly verified in sample projects. The available project descriptions provide no statements on the pure generation of knowledge with the help of 3D models. One can only infer their intention by certain images. This conclusion has been made after analyzing fifteen recent projects on settlement research and reconstruction in depth.

The only project that explicitly describes this aim in the project's documentation is a research project of the University of Tübingen. The project "Virtual Archaeology", which investigates the ancient ruined city of Troy in present day Turkey, was part of the joint research project under the leadership of Dr. Jablonka from the University of Tübingen (Jablonka 2004). In the final report on the project Mr. Kirchner, head of the virtual part of the work, describes the working system for the archaeologists as a digital tool based on digital excavation data. Unfortunately, the Troy working system could not be found as a running application in any other project at present. Therefore, it is not possible to prove the reusability and sustainability of the system.

Empirical Studies

In order to define the real needs and expectations for the use of 3D models in settlement research, questionnaires were developed and surveys were undertaken. Experts and laymen were asked about their specific needs and expectations of 3D models. As part of a BMBF (German Ministry of Education and Research) funded project, a large survey with 18 scientists was conducted, as well as a further survey with 93 lay people.

Interview of Experts

In order to investigate the common use of 3D models, a survey of experts in the fields of archaeology, history and geography was carried out. The main goal of the survey was to find out how researchers use 3D models and how great the demand is for using 3D models in the near future. The experts were also asked for their personal level of skill with 3D modelling. Researchers from all over Germany were interviewed in the summer of 2006.

Those in the test group had to have worked with settlement projects and computers or had interest in

working with computers. The evaluations of the answers that were given show mainly that:

50% of the researchers have used pre-constructed 3D models for their studies. The experts were not skilled in creating models themselves; 3.59 on a scale from 1 to 5, with 1 as the highest, was the average knowledge in CAD Software such as AutoCAD. Only a 4.5 average knowledge was demonstrated in 3D modelling software such as Autodesk 3dsMax. For the research work, volume models with simple geometry seem to be efficient for building structures. It was thought that pathway systems should be textured, and that vegetation was not at all needed in 3D for scientific results. A majority showed interest in working with 3D models in the future for work based on excavation data (1.22 on a scale from 1 to 5).

Survey of Laymen

It is commonly assumed that the scientific requirements for 3D models do not correspond with the desires of non-professionals. In order to investigate and prove or disprove this theory, a survey with non-professionals was also carried out. The survey was done first with a target group of older people, because as opposed to younger generations, older people are generally less used to 3D presentations. This fact helps to create a very objective view of the used technology and helps to support the direct connection between scientist and the user/viewer of presentations.

To evaluate the potential of presenting settlements with digital media a lecture with a survey integrated into it was held. The location of the survey was the University of Applied Sciences in Bernburg. Ninety-three retired people attended the lecture and survey. The average age was 68 years. The described scenario was the use of presentations on settlement reconstruction at a computer terminal in a local museum.

The main results were: The interviewed people wished to see mostly films including real scenes (42%) followed by 3D virtual presentations (34%). With a majority of 80%, the visitors of the presentation wanted to navigate actively through the content of the computer station. Only 5% wanted to be completely passive. 56% of the people wanted to either navigate in the models along predefined pathways or wanted to see the models as a single rendered image. A minority of 16% wanted to be fully interactive by navigating in real time. This finding emphasizes the known dilemma of "Lost in Space".

Another often-discussed aspect is the question of uncertainty in digital presentations about the past. The question was asked if the test persons wanted to see the process of science by having more then one hypothesis about the past presented to them. On a scale from –3 (No, not at all) to +3 (Yes, definitely) the test group selected an average of 1.59. This means the visitors wanted to see various hypotheses about the past rather than one "historic truth." Interestingly, both poles of scientific and public opinion appear to be closer together than thought before the survey. This should give new impetus to the use of 3D models both by professionals and for non-professionals.

Conclusion and Outlook

A number of research hypotheses for the use of 3D models have been stated and will be evaluated in forthcoming papers. It is safe to say that the connection between old and new working methods in the field of settlement research has not yet been established for practical use. This may lie in the fact that the value of 3D models beyond static presentations has not yet been proven. The promising approach of the London Charter initiative has to be kept in motion and needs to be specialized for settlement research and analysis.

The surveys conducted show that there is a closer relationship between the scientific requirements and the use of 3D models for laymen than previously supposed. This could motivate researchers to also use the working models for museums and other exhibits without completely rebuilding them in a time-consuming process. By doing this, the process-oriented approach of this interdisciplinary field of research, which requires a high level of communication, will be more strongly emphasized.

Finally, it has been shown that the use of 3D models with additional media and data, such as GIS, supports the work process. Further research needs to be carried out on projects like the OSCAR platform, a research project of the University of Applied Sciences, Dessau (Open Settlement and Communication platform for settlement research, www.oscar-project.com). The aim of connecting different media needs to be supported by scientific methods. This includes the fact that digital applications have to be more strongly supported by analog research theory.

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